METHOD AND DEVICE FOR GENERATION OF A CHARGE IMAGE VIA EXPOSURE LINES WHOSE DEVIATIONS FROM A TARGET LINE ARE MINIMIZED

The present invention concerns a method and a device for generation of a charge image on an intermediate carrier of an electrophotographic printer or copier with the aid of a character generator that has a plurality of light sources arranged in at least one row, whereby the at least one light source row is imaged on the intermediate carrier as an exposure line and the intermediate carrier is movable essentially transverse to the exposure line relative to the character generator.

A character generator with a plurality of light sources that are arranged in a row is known from EP 0 971 310 B1. The light source row is imaged as an exposure line on an intermediate carrier of a printer or copier and thereby generates a line of a latent charge image on a photoconductive coating of the intermediate carrier. Each light source of the character generator is thereby provided for generation of an image point of the charge image, meaning that the arrangement density of the light sources on the character generator corresponds to the resolution of the image.

The intermediate carrier is moved transverse to the exposure line direction relative to the character generator so that a two-dimensional charge image is generated on the intermediate carrier via successively imaged exposure lines. For this the intermediate carrier is, for example, formed as a photoconductor drum that rotates around its center axis or as a revolving photoconductor belt. The charge image on the intermediate carrier is developed in a known manner and the developed image is transfer-printed onto a recording medium.

Since the light sources of the character generator are directly imaged on the intermediate carrier in an exposure line, mechanical imprecision, both in the orientation of the character generator relative to the intermediate carrier and within the character generator (for example in the arrangement of the light sources, the

optics [sic], or due to mechanical warpings), can lead to a deviation of the exposure line from a target line. The precision in the design and installation of the character generator that is required for generation of a satisfactory print image requires a significant expenditure and incurs significant costs in present-day printers and copiers.

Particularly high requirements for the precision are posed in color printing according to what is known as the "single pass" method in which a recording medium (for example a single sheet of paper or reel paper) is guided through a plurality of separate imaging units that respectively contribute a color component of a color image (for example red/green/blue or cyan/magenta/yellow/black). Each of these imaging units has a character generator of the type cited above. When the exposure line of one or more of these character generators deviates from the associated target line, the colors are not combined as intended; rather, color adulterations result that have a very disruptive effect.

The invention is based on the object to specify a method and a device that enable the generation of a charge image of high-quality charge image at moderate expense.

According to the invention this object is achieved via a method with the features of the claim 1 and via a device with the features of the claim 12. Advantageous developments of the invention are specified in the further claims.

Instead of minimizing imaging errors via ever-greater precision in the design and installation of the character generator, it is accordingly proposed to accept certain structurally dependent imaging errors and to correct these errors via a suitable selection of the temporal beginning of the illumination phases of individual light sources or of groups of light sources.

For better understanding of the present invention, in the following reference is made to the preferred exemplary embodiment shown in the drawings, which preferred exemplary embodiment is described using specific terminology. However it is noted that the protective scope of the invention should not thereby be limited since such alterations and further modifications to the shown device and method as well as such further applications of the invention as they are indicated therein are viewed as typical present or future expert knowledge of an average man skilled in the art. In addition to a representation of the prior art, the Figures show an exemplary embodiment of the present invention, namely

Figure 1 a schematic representation of the design and the functionality of a character generator according to the prior art,

Figure 2 a schematic representation of the design and the functionality of a character generator according to a development of the invention and

Figure 3 a schematic representation of an exposure line generated according to the prior art and of an exposure line generated according to a development of the invention.

The design of a character generator 10 known from the prior art is schematically shown in Figure 1. The character generator 10 is described in detail in the aforementioned EP 0 971 310 B1, whose content is incorporated by reference into the present specification. The character generator 10 has a light source row that is formed from 12,288 LEDs over a breadth of 20.48 inches. The LEDs are, for example, imaged onto an intermediate carrier (not shown) in an exposure line via a SELFOC lens, whereby each LED is specified for generation of one image point. A print image resolution of 600 dpi (dots per inch) results from the number of the LEDs and the length of the LED row.

As is shown schematically in Figure 1, the LED row is made up of separate LED groups 12 (LED arrays) that are respectively connected with an associated functional unit 14 for control of the LEDs. In the depicted exemplary embodiment the functional unit 14 is formed by an integrated circuit. The conventional character generator 10 from Figure 1 typically has 192 LED groups 12 with respectively 64 LEDs and an associated functional unit 14. In addition the character generator 10 has a central control unit 16 (LEDPAC, LED Print Array Controller) for controlling the character generator 10.

In the following the conventional method for generation of a charge image on an intermediate carrier with the aid of the conventional character generator 10 is briefly explained. The central control unit 16 sends print data via a data line 18 into a shift register 20 of first functional unit 14 (i.e. the functional unit 14 arranged furthest left in Figure 1). The functional units 14 adjacent to shift register 20 are connected with one another via lines 22 and the print data are forwarded by the shift register 20 to all functional units 14 until the shift register 20 of the last functional unit 14 (i.e. the functional unit (14) arranged furthest to the right in Figure 1) is filled with print data.

The print data are made up of an eight bit-long data word for each LED of the character generator 10, which data word represents the duration of the illumination phase of the corresponding LED. The illumination phase duration is thereby the product of two factors, namely an intended illumination intensity on the one hand and a correction factor on the other hand. In the simplest case the intended illumination intensity can be represented by a one bit signal (LED on or LED off). This is designated as bi-level printing. However, for generation of a plurality of gray tones it is advantageous to provide a plurality of degrees of illumination intensity, i.e. illumination phases of different length. This method is called multilevel printing, typically with four, eight or 16 degrees of illumination intensity. The correction factor serves to compensate fluctuations in the individual

luminosity of the LEDs that result as a consequence of aging or irregularities in the manufacturing.

After the shift registers 20 of all functional units 14 of the character generator 10 are filled with print data they are transferred into a buffer 24 (latch L). With the aid of a driver 26 (driver D), the LEDs of the associated LED array 12 are then simultaneously switched on and are switched off again after the corresponding illumination phase duration (stored in intermediate memory 24) has elapsed (given an illumination phase duration of length 0, the corresponding LED is just not switched on at all). During the illumination phase of the LEDs the print data for exposure of the following line are placed in the shift register 20 of all functional units 14. Further details regarding design and function of the functional units 14 are found in the aforementioned EP 0 971 310 B1 and should not be stated further here.

The LED row of the character generator 10 is imaged onto an intermediate carrier 30 as an exposure line 28 with the aid of a known SELFOC optic (not shown) (see Figure 3), which intermediate carrier 30 moves with a velocity v_0 relative to the character generator 10 in the direction of the velocity arrow shown in Fig. 3.

Due to mechanical imprecisions in the design of the character generator 10 or in the installation of the character generator 10 in a printer or copier, the exposure line 28 can deviate from a target line 32. In the schematic representation of Figure 3 the vertical lines indicate the boundaries of the LED array 12, meaning that the segments of the exposure line 28 that are located between two vertical lines are produced by precisely one LED array. For the sake of simplicity the exposure line 28 is subdivided into only eight segments in the simplified representation of Figure 3, meaning that the character generator corresponding to this simplified representation would possess only eight LED arrays.

In the conventional character generator 10 the deviations of the exposure line 28 from the target line 32 can be kept small only via enormous mechanical expense. In particular continuous, smooth deviations of the exposure line 28 from the target line 32 as are shown in Figure 3 are typical, which deviations result, for example, from warping or a sagging of the character generator 12. Such deformations can be remedied only with difficulty via readjustment.

In black-and-white printing a tolerably smooth, uniform deviation of the exposure line 28 from target line 32 in the resulting print image will possibly not be regarded as disturbing because it is not visible with the naked eye without further measures. In contrast, given "single-pass" color printing in which a plurality of character generators contribute to the generation of the color components of a color image, such deviations lead to a disturbance of the color convergence and are absolutely unacceptable.

A character generator 34 according to a development of the present invention is shown in Figure 2. Similar to character generator 10 from the prior art, in the character generator 34 the light sources are formed by LED groups 36 (LED arrays) that are controlled via an associated functional unit 38. The character generator 34 also possesses a central control unit 40. The essential difference from the prior art exists in the design of the functional units 38 and in the operation of the character generator 34, as is described in the following.

Instead of the shift register 20, the character generator 34 possesses an internal bus 42 and a volatile memory (RAM 44). Moreover, each functional unit 38 of the character generator 34 has a separate control unit (controller C) 46. The internal data bus 42 has sixteen data lines and optionally has a seventeenth command line. It is an internal bus insofar as it merely establishes a connection between the functional units 38 that are thus operatively arranged in a row. Each functional unit 38 has an input interface 50 via which it can receive data and a clock signal from the preceding functional unit in the row (situated to the left in Fig. 2) and an

output interface via which the functional unit 38 can relay data and a clock signal to the following functional unit in the row (situated to the right in Figure 2). A system clock in which the clock signal is reproduced lies between reception and forwarding of data by a functional unit 38. Each functional unit 38 has an address and an address decoder (not shown) so that it can be addressed in targeted fashion.

In the following the functioning of character generator 34 is explained. The central control unit 40 sends the print data to the appertaining functional unit 38 via the internal bus 42. A special data protocol is used for this that can also transfer control information in addition to data packets. Among other things, the address of that functional unit 38 for which the data packet is designated belongs among such control information. As described above, the data and control information are passed through all functional units 38. When a functional unit 38 thereby recognizes (using the address contained in the control information) that the data are destined for it, it stores these data in its memory 44.

The print data are essentially identical to those of the character generator 10 of the prior art. However, in the character generator 34 only the sought illumination intensity for each LED is required, but not its correction factor (which is independent of the print image). Instead of this, the correction factors are stored in the memory 44. The data quantity required for printing of a line is thereby significantly reduced.

The main difference of the function of character generator 34 relative to that of the conventional character generator is that not only the length of the illumination phases of the LEDs is individually controlled, but rather also their beginning, at least per groups. For each LED group 36, the central control unit 40 provides the beginning of the illumination phase of the LEDs. This means that the illumination phases of all light sources within a group are initiated by a common activation (in this case by the central control unit 40).

Since the intermediate carrier 30 moves relative to the character generator, a temporal displacement of the illumination phase effects a spatial displacement of the corresponding segment of the exposure line 28 on the intermediate carrier 30. This displacement is utilized in order to minimize deviations of the exposure line 28 from the target line 32.

The method is explained in more detail with reference to Figure 3. First it is noted that the illumination phases are extremely short in relation to the velocity v_0 with which the intermediate carrier 30 moves relative to the character generator 34 or, respectively, 10, since otherwise the charge image would be smudged. For explanation of the method, we consider two exemplary points 52 and 54 of the exposure line 28 from Figure 3. The exposure points 52 and 54 were generated "simultaneously", i.e. the illumination phases of the two corresponding LEDs began at the same time (called the reference point in time in the following) and the durations of the illumination phases are negligible in this context.

As is to be learned from Figure 3, the exposure point 52 is offset in relation to the target line 32 by a distance d_1 in the direction of the relative velocity v_0 of the intermediate carrier 30 relative to the character generator 10, or 34. This means that the exposure point 52 would lie on the target line if the corresponding LED had been switched on at a time $t_1 = d_1 / v_0$ after the reference point in time. In contrast, the exposure point 54 is offset in relation to the target line 32 by a distance d_2 opposite the direction of the velocity v_0. Accordingly, the deviation of the exposure point 54 from the target line 32 can be corrected in that the illumination phase of the corresponding LED is brought forward by $t_2 = d_2 / v_0$ relative to the reference point in time.

In this way the deviation of each exposure point from the target line 32 can in principle be corrected. In order to limit the expense both of the control logic and of the quantity of the data to be transmitted, it is advantageous to predetermine to determine the beginning of the illumination phase for all LEDs of an LED group

36 in the context of a common activation instead of individually for each LED. As a rule this means that the illumination phases of the LEDs of a group essentially begin simultaneously.

The result of this method is shown in the exposure line 56, which corresponds in principle to the exposure line 28 except that the temporal beginning of the illumination phase for each LED group 36 has been selected such that the corresponding segment of the exposure line 56 deviates as little as possible from the target line 58.

Given the character generator 34 in Figure 2 the central control unit 40 sends the signal for the beginning of the illumination phase of each LED group 36 to the corresponding functional unit 38. Upon receipt of the signal, the control unit 46 individual to the functional unit 38 initiates the beginning of the illumination phase with the aid of a driver 60 that does not significantly differ from driver 26 of the conventional character generator 10.

As is to be seen in Figure 3, discontinuities arise in the exposure line 56 when the temporal beginning of the illumination phase of adjacent LED groups 36 differs. This means that the temporal beginning of the illumination phases in adjacent LED groups may not differ too significantly because otherwise discontinuities in the print image would be visible. In order to receive an impression of the scale of the corrections that can be achieved with the character generator 34 and the presented method, we put forward that the exposure line stands oblique to the target line given a simultaneous beginning of all illumination phases. When an offset of half the size of a pixel is tolerated at the boundaries of the exposure line segments, given 192 LED groups and a pixel size of 1/600 inches one receives a compensable total offset of the ends of the character generator 34 of 4.06 mm, which is a multiple of the imprecision with which one typically has to deal.

It results due to the temporal shifting of the illumination phases that the character generator simultaneously generates segments of different exposure lines. When a spatial offset of half a pixel size is again tolerated at the segment boundaries of an exposure line, given the above example of the obliquely situated character generator segments of half as many lines as the character generator 34 has LED groups 36 are simultaneously printed. In the shown exemplary embodiment of the character generator 34 in Figure 2 this means that segments of 96 different print lines are generated simultaneously. Therefore the memory 44 should have space for the print data of at least 96 lines.

In the depicted exemplary embodiment the beginning of the illumination phase of each LED group is predetermined by the central control unit 40. Since the temporal offset of the illumination phase beginning of each LED group 36 (which temporal offset minimizes the deviation of the corresponding segment of the exposure line 56 from the target line 58) is independent of the print data, this offset could also be stored in the memory 44 of each functional unit 38 and the activation of the LED group 36 could be initiated by the control unit 46 with suitable offset in relation to a reference point in time.

Although a preferred exemplary embodiment is shown and described in detail in the drawings and the preceding specification, this should be viewed as purely exemplary and not as limiting the present invention. It is noted that only the preferred exemplary embodiment has been presented and described, and all alterations and modifications that presently and in the future lie within the protective scope of the invention should be protected.

Reference list

10	character generator
12	LED group
14	functional unit
16	central control unit
18	data line
20	shift register
22	line
24	buffer
26	driver
28	exposure line
30	intermediate carrier
32	target line
34	character generator
36	LED group
38	functional unit
40	central control unit
42	internal data bus
44	volatile memory
46	control unit
48	input interface
50	output interface
52	exposure point
54	exposure point
56	exposure line
58	target line
60	driver